

# Nano-scale Analysis of Chemical State and Structure for LIB Cathode Materials

Scanning Transmission X-ray Microscope (STXM) has a spatial resolution of  $\sim 40$  nm and a high energy resolution. STXM is a useful method to evaluate chemical states and crystal structures in a nano-scale region. Therefore, the charge state and the degradation of LIB cathode can be investigated by using the advantage of STXM analysis.

## STXM (Scanning Transmission X-ray Microscope) $\rightarrow$ Nano-scale XAFS analysis

- Spatial resolution :  $\sim 40$  nm
- Measurable Elements: C, O, Si(K-edge) Ti, Mn, Fe, Co, Ni, Zn(L-edge), etc.

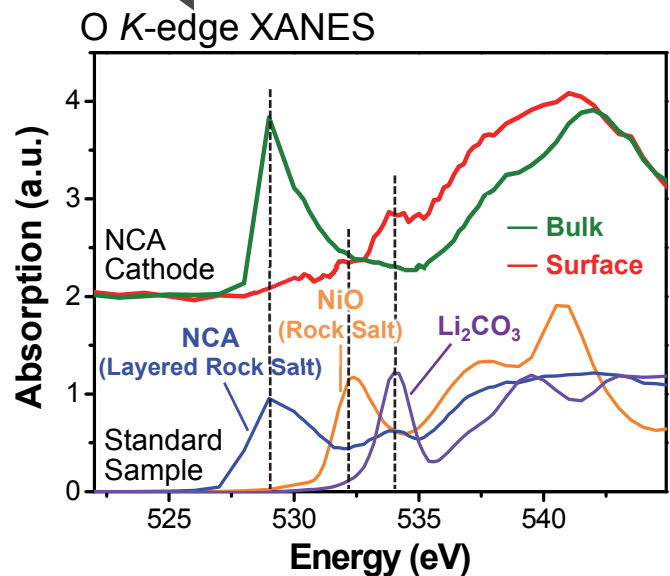
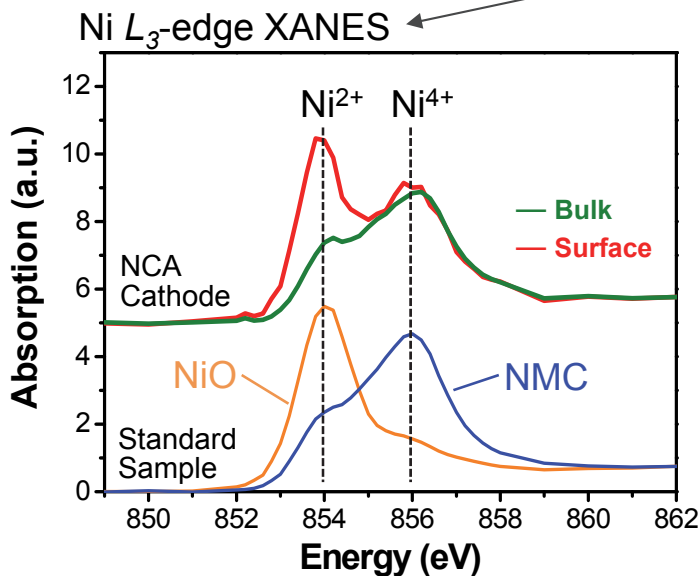
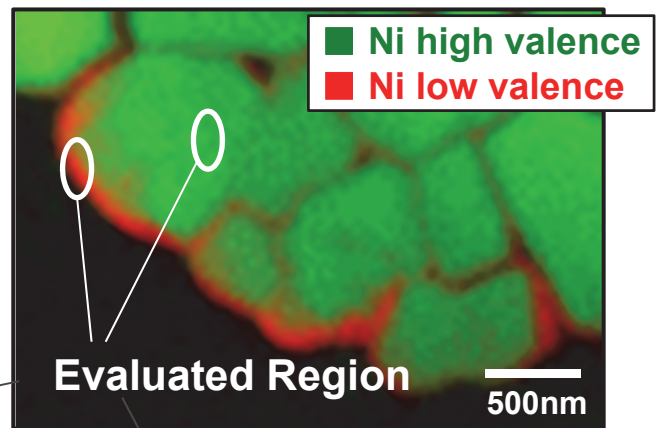
STXM image of Ni valance distribution in NCA cathode

sample:  $\text{Li}(\text{Ni}_{0.8}\text{Co}_{0.15}\text{Al}_{0.05})\text{O}_2$   
(4.2 V (vs.  $\text{Li}/\text{Li}^+$ ))

Spatial distribution analysis for  
**Chemical State** and **Structure**

Ni  $L_3$ -edge  $\rightarrow$  Ni Valence

O  $K$ -edge  $\rightarrow$  Crystal Structure



Region	Averaged Ni valence	Structure	Chemical State
Bulk	3.5+	Layered Rock Salt	Structure of charge state NCA was maintained
Surface	2.6+	Rock Salt, $\text{Li}_2\text{CO}_3$	Surface degradation layer including $\text{NiO}$ , $(\text{LiNi})\text{O}$ , $\text{Li}_2\text{CO}_3$ was formed

Nano-scale distribution of charge state and degradation for LIB cathode can be evaluated